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Institute for Computational Mechanics in Propulsion (ICOMP)

First Year Summary

First Annual Report
produced by the ICOMP Steering Committee
September 16, 1985 through December 31, 1986

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November 1987

INSTITUTE FOR COMPUTATIONAL MECHANICS IN PROPULSION (ICOMP)

First Year Summary

ICOMP FIRST ANNUAL REPORT
SEPTEMBER 16, 1985 THROUGH DECEMBER 31, 1986

SUMMARY

The Institute for Computational Mechanics in Propulsion (ICOMP) is operated jointly by Case Western Reserve University and the NASA Lewis Research Center in Cleveland, Ohio. The purpose of ICOMP is to develop techniques to improve problem-solving capabilities in all aspects of computational mechanics related to propulsion. The Institute began operation in 1985. This report describes the events leading to its formation, its organization and method of operation, and the technical activities of the first year.

E-3844

INTRODUCTION

The Institute for Computational Mechanics in Propulsion (ICOMP) was established in September, 1985 through a Space Act Agreement, under the auspices of Case Western Reserve University and the NASA Lewis Research Center. The Institute is intended to provide a means for researchers of various levels of experience and expertise to spend periods of time in residence at the Lewis Research Center, performing research directed toward the improvement of computational capability in the many broad and interacting disciplines of interest in aerospace propulsion. This is the first "annual" report of ICOMP. The report covers the history of ICOMP, its activities from its inception through December 1986, and a brief overview of its activities of 1987.

HISTORY OF ICOMP

ICOMP began with a request from NASA Headquarters in April, 1981 asking Lewis to examine ways in which the capability of the Institute for Computational Analysis in Science and Engineering (ICASE) at Langley Research Center might be brought to bear on problems at Lewis Research Center. One result was to bring ICASE researchers to Lewis to work with Lewis staff members on problems of interest. From this, it appeared certain that there would be merit in establishing a computational institute at Lewis.

A Research Institute for Advanced Computer Science (RIACS) was being formed at Ames Research Center using ICASE as a model. A committee of Lewis researchers was formed to review ICASE and to consider concepts for a computational institute at Lewis including methods of operation and the scope of research. The planning committee including representatives from six universities met on March 14, 1984. The committee reviewed the then current and proposed research at Lewis, concluding that an institute be formed, and that "the thrust of the institute should be in computational mechanics, stressing engineering rather than mathematics, and emphasizing research in highly nonlinear (discontinuous even) interacting systems."

The planning committee also recommended that a workshop be held to define the scope more explicitly within that broad thrust. A workshop for this purpose was held at Lewis on September 24-25, 1984 which brought together experts in structural mechanics and fluid mechanics from universities and industry. There was uniform agreement that the institute be formed and that the scope be: to advance the understanding of aerospace propulsion physical phenomena; to improve computer simulation of aerospace propulsion components; and to focus interdisciplinary computational research efforts.

It was agreed that the broad computational research areas of interest would include:

Computational fluid mechanics for internal flow;
Computational structural mechanics and dynamics;
Multivariable control theory and applications; and
Computational chemistry and material science.

With the uniform agreement that such an institute would fill a gap in propulsion research, funds to form the institute were requested and allocated in the FY85 budget. This new institute, the Institute for Computational Mechanics in Propulsion, began operation on September 16, 1985

THE ORGANIZATION

This section describes the nature of the agreement established between NASA Lewis and Case Western Reserve University for the operation of ICOMP. Due to formalities which precluded the establishment of a formal management structure, a Space Act Agreement was formulated with Case Western Reserve University.

Introduction/Statement of Purpose

The Lewis Research Center has the lead responsibility within NASA for research in aerospace propulsion. The research generally involves highly nonlinear interacting phenomena and technology, much of which can be simulated only by numerical computation using modern computers.

The many broad and interacting disciplines of interest in aerospace propulsion include fluid mechanics, aerodynamics, heat transfer, structures, controls, and materials. To take full advantage of the capability of present and future generations of modern, large computers requires the further development of computational codes that are compatiable with both the categorical needs of the problems and the computer architectures.

In order to enable NASA Lewis and the interested scientific and technical community to move forward rapidly in these areas, a Space Act Agreement was entered into for the founding of an Institute for Computational Mechanics in Propulsion (ICOMP) under joint CWRU/NASA Lewis auspices. Such an institute is intended to provide a means for researchers of various levels of experience and expertise to spend periods of time in residence at NASA Lewis toward the improvement of computational capability in the aforementioned areas of propulsion research.

Organizational Structure

The Institute reports to the Director of NASA Lewis and to the Dean of Case Institute of Technology as shown in the accompanying organizational chart (fig. 1.). The operation of the Institute is through a steering committee and its chairman. Administrative services to ICOMP are provided through Case Institute of Technology and NASA Lewis.

The research personnel employed by the Institute are formally supervised by the steering committee through its chairman. The formal liaison between the Institute and its research constituencies is through the chairman of the steering committee.

Steering Committee

The steering committee is composed of representatives from NASA Lewis appointed by the Director of the Center and representatives from Case Institute appointed by the Dean. The Chairman is elected from among the members of the steering committee.

The steering committee is the policy-making board of the Institute operating under the broad guidelines determined by the Director of NASA Lewis and the Dean of Case Institute of Technology. It meets regularly to deal with all necessary matters. The CWRU and Lewis members of the Steering Committee ensure that all activities and policies of the Institute are consistent with the aims and objectives of their respective organizations. The original composition of the Steering Committee is shown in figure 2.

Chairman

The chairman of the Steering Committee has the authority and responsibility to implement the research and administrative policies set by the steering committee in carrying on the operation of the Institute. However, the Director of NASA Lewis, or his designee, shall have authority to decide the level of NASA funding to ICOMP on a yearly basis.

Research Personnel

Research Personnel, administratively, are employees of, or visitors to Case Western Reserve University and therefore subject to the employment rules, employee benefits, travel protocols, etc., and all other policies of the university. All terms used in describing their status are interpreted in the same way that they pertain to said university's employees.

Research personnel are full-time or part-time, but in any case shall be nontenure-track. They may be accorded the designations Research Associate, Senior Research Associate, or other university designation, according to their qualifications and as appropriate to their status at the Institute. Salaries will be according to qualifications and experience.

Administrative Services

Administrative services are provided by Case Western Reserve University. This includes complete fiscal management of the Institute, hiring of research personnel, provision of employee benefits, as appropriate, and maintenance of employee records. The University attorney's office will be available to help clarify the visa status of any visitor to the Institute who is not a U.S. citizen. The University, however, according to its established policy will not pursue permanent residence status for other than tenure-track faculty.

The administrative services will be provided through an Executive Officer (who may also be a member of the steering committee) and the part-time services of an administrative aide. In December 1986, Dr. Charles Feiler was approached to serve as Executive Officer. Darleen Midkiff serves as the Case Western administrative aide. Mrs. Sheila Nussbaum was the Lewis aide until replaced by Mrs. Frances Pipak in 1987. Professor Lavery resigned from the Steering Committee to assume a NASA position.

Services Provided by NASA LeRC

The Institute and its research personnel will be provided the following at no cost to the Institute: office space for Institute personnel, use of NASA computer facilities, and organizational services for workshops under joint NASA-ICOMP auspices; however, the exact location of office space, its quantity, the amount and kind of furnishings therefore, and the amount and times for use of NASA computer facilities shall only be provided as determined to be available by the Director of NASA Lewis, or his designee.

ICOMP Budget

The yearly budget includes the support of CWRU personnel who provide administrative services and who serve on the steering committee. It includes also the salaries of the Institute research personnel, together with provision for the fringe benefits of eligible participants and projected travel for Institute personnel other than Federal Government employees.

Independent Responsibility

This Agreement is not intended to constitute, create, give effect or otherwise recognize a joint venture, partnership or formal business organization of any kind, and the rights and obligations of the parties shall be only those expressly set forth herein. Each party shall remain independently responsible for all of its own costs and expenses in connection with the conduct of the Institute contemplated by this Agreement, except as is otherwise provided herein.

Points of Technical Contact

As specified in the Space Act Agreement, the points of responsible technical contact for each party shall be as follows:

For CWRU
Professor Eli Reshotko
Professor of Engineering
Case Institute of Technology
Case Western Reserve University
University Circle
Cleveland, Ohio 44106
(216) 368-6447

For NASA
Dr. Louis A. Povinelli, NASA Coordinator
Deputy Chief, Internal Fluid Mech. Div.
Mail Stop 5-3
21000 Brookpark Road
Cleveland, Ohio 44135
(216) 433-5818

THE ICOMP STAFF OF VISITING RESEARCHERS

The heart of ICOMP is its staff of visiting researchers, assembled from around the world. These people bring their expertise in computational fluid mechanics and structural mechanics to Lewis to advance the state-of-the-science and to interact with the Lewis staff. The composition of the ICOMP staff through calendar year 1986 is shown figure 3. From its inception to the end of 1986 there were 23 visiting researchers who were in residence for periods ranging from two weeks to a year. The "high season" occurred during July and August when 14 to 15 people were in residence. As shown by figure 3, six people were associated with structures and 17 with fluid mechanics. Figures 4 and 5 show ICOMP visitors and some of the ICOMP Steering Committee members at two different times during the year.

REPORTS AND SEMINARS BY THE ICOMP STAFF

Reports

Balarini Roberto (CWRU), and Plesha, Michael E. (ICOMP): "The Effects of Crack Surface Friction and Roughness on Crack Tip Stress Fields." ICOMP Report No. 87-1, February 1987, 17 pages.

A model is presented which can be used to incorporate the effects of friction and tortuosity along crack surfaces through a constitutive law applied to the interface between opposing crack surfaces. The problem of a crack with a saw-tooth surface in an infinite medium subjected to a far-field shear stress is solved and the ratios of Mode-I stress intensity to Mode-II stress intensity are calculated for various coefficients of friction and material properties. The results show that tortuosity and friction lead to an increase in fracture loads and alter the direction of crack propagation.

Chima, Rodrick V.(NASA Lewis), Turkel, Eli (ICASE), and Schaffer, Steve (ICOMP): "Comparison of Three Explicit Multigrid Methods for the Euler and Navier-Stokes Equations." ICOMP Report No. 86-3, 1986, 15 pages.

Three explicit multigrid methods, Ni's method, Jameson's finite-volume method, and a finite-difference method based on Brandt's work, are described and compared for two model problems. All three methods use an explicit multistage Runge-Kutta scheme on the fine grid, and this scheme is also described. Convergence histories for inviscid flow over a bump in a channel for the fine-grid scheme alone show that convergence rate is proportional to Courant number and that implicit residual smoothing can significantly accelerate the scheme. Ni's method was slightly slower than the implicitlysmoothed scheme alone. Brandt's and Jameson's methods are shown to be equivalent in form but differ in their node versus cell-centered implementations. They are about 8.5 times faster than Ni's method in terms of CPU time. Results for an oblique shock boundary layer interaction problem verify the accuracy of the finite-difference code. All methods slowed considerably on the stretched viscous grid but Brandt's method was still 2.1 times faster than Ni's method.

Givi, Peyman (ICOMP), and Kosaly, George (U. of Washington): "On the Coalescence-Dispersion Modeling of Turbulent Molecular Mixing," ICOMP Report No. 87-3, July 1987, 24 pages.

The general coalescence-dispersion (C/D) closure provides phenomenological modeling of turbulent molecular mixing. The models of Curl, and Dopazo and O'Brien appear as two limiting C/D models that "bracket" the range of results one can obtain by various models. This finding is used to investigate the sensitivity of the results to the choice of the model. Inert scalar mixing is found to be less model-sensitive than mixing accompanied by chemical reaction. Infinitely fast chemistry approximation is used to relate the C/D approach to Toor's earlier results. Pure mixing and infinite rate chemistry calculations are compared to study further a recent result of Hsieh and O'Brien who found that higher concentration moments are not sensitive to chemistry.

Lin, Chin-Shun (ICOMP): "Numerical Calculations of Turbulent Reacting Flow in a Gas-Turbine Combustor." ICOMP Report No. 87-2, April 1987, 20 pages.

A numerical study for confined, axisymmetrical, turbulent diffusion flames is presented. Local mean gas properties are predicted by solving the appropriate conservation equations in the finite-difference form with the corresponding boundary conditions. The k-e two-equation turbulence model is employed to describe the turbulent nature of the flow. A two-step kinetic model is assumed to govern the reaction mechanism. The finite reaction rate is the smaller of an Arrhenius type of reaction rate and a modified version of eddy-breakup model. Reasonable agreement is observed between calculations and measurements, but to obtain better agreement, more work is needed on improvements of the above mathematical models. However, the present numerical study offers an improvement in the analysis and design of the gas turbine combustors.

Plesha, Michael E. (ICOMP), and Steinetz, Bruce M. (NASA Lewis): "A Constitutive Law for Finite Element Contact Problems with Unclassical Friction." ICOMP Report No. 86-1, November 1986, 19 pages.

This report addresses techniques for modeling complex, unclassical contact-friction problems arising in solid and structural mechanics. A constitutive modeling concept is employed whereby analytic relations between increments of contact surface stress (i.e., traction) and contact surface deformation (i.e., relative displacement) are developed. Because of the incremental form of these relations, they are valid for arbitrary load-deformation histories. The motivation idealizations can be implemented in finite element analysis software in a consistent, straightforward manner. Of particular interest in this report is modeling of two-body (i.e., unlubricated) metal-metal, ceramic-ceramic, and metal-ceramic contact. Interfaces involving ceramics are of engineering importance, ceramics being considered for advanced turbine engines in which higher temperature materials offer potential for higher engine fuel efficiency.

Seminars

Professor Fred A. Akl, Ohio University: "Parallel Processing of Large Finite Element Systems."

Consider a parallel processor with (n+1) processors. The first n processors are designated as domain processors and the last processor, (n+1)st, is referred to as a global processor. A finite element model can be divided into n domains each of which is assumed to possess m elements. The multi-frontal soluion method offers a new parallel algorithm for the solution of the generalized eigenproblem KD = MDL, typically encountered in finite element modelling of linear systems. It is based on the classical frontal solution method for the solution of linear simultaneous equations and the modified subspace method for the solution of the generalized eigenproblem. Each domain processor is assigned to solve for the degrees of freedom (DOF) within each domain exclusive of those DOF located along the boundary. Concurrent analysis is realized by using each processor to create the stiffness and mass matrices of the elements located within its assigned domain, and by performing simultaneous assembly forward elimination and back-substitution for each domain. The modified subspace eigenanalysis method also exploits parallelism by projecting the stiffness and mass matrices onto the required subspace in each iteration within each domain. The global processor is assigned the task of solving for the DOF located along the global front which is comprised of the DOF located along the boundaries of all domains. It is also given the task of solving the auxiliary eigenproblem of the finite element model which arises by summing the contribution of the domains to the current subspace iteration. The multi-front can be visualized as sweeping all domains concurrently in forward then backward directions. This process can be repeated until the set of subdominant eigenpairs of the required subspace are determined to a specified degree of accuracy.

Dr. Peyman Givi, Flow Research Company: "Fundamental Studies of Turbulent Combustion and Spray Combustion."

A summary of ongoing efforts in using direct numerical simulations (DNS), random-vortex methods and probability density function (PDF) techniques in the computational studies of turbulent reacting flows will be presented. A brief summary of recent experimental efforts on colliding fuel droplets will also be given.

Professor John Lavery, Case Western Reserve University: "Solution of Nonlinear Systems: Does Low-Order Convergence Outperform High-Order Convergence?"

When solving nonlinear systems, one expects high-order methods to outperform low-order methods. Theoretical results on the relative performance of high-order and low-order methods in a sufficiently small neighborhood of a solution lend credence to this belief. Initial guesses are, however, rarely close to the solutions. When the approximate solution is far from the exact solution, low-order methods can be faster than high-order methods. Criteria that can be used to select an appropriate low-order method will be discussed.

Professor Fred Lyman, Syracuse University: "Effect of Large-Scale Coherent Eddies on Boundary-Layer Flow and Heat Transfer - A Prospectus for Proposed Research."

The purpose of this seminar is to initiate discussion on a proposed research project involving vortex interaction with solid surfaces, a problem which is relevant to turbine-blade heat transfer. Some, as yet unexplained, experimental results which motivated this proposal will be briefly described. Approaches to analytical-numerical modeling of the problem will be discussed. The intent of the seminar is to stimulate as much interaction as possible with interested Lewis researchers while the problem is in its formative stages.

Professor Fred Lyman, Syracuse University: "Two Problems in Vortex-Surface Interaction."

Two problems concerning the interaction of vortices with solid bodies will be discussed. The first is the effect of a discrete vortex on the flow and heat transfer in a boundary layer. This is a simple model of what happens when vortices shed from a stator vane interact with a rotor blade. The vortex produces strong, rapid pressure fluctuations near the leading edge, which make it difficult either to obtain a local solution or to utilize the usual downstream marching techniques to solve the two-dimensional unsteady boundary-layer equation. A series truncation (or Galerkin spectral) method which avoids these difficulties will be described. The second problem, which is still in its formative stages, was formulated to provide an alternative explanation for the observed variation of total temperature in the wake of compressor stator vanes. An inviscid vortex interaction model is developed to predict the pressure fluctuations around the stator blade, which are responsible for changes in the total temperature.

Professor Steve Schaffer, University of Utah: "Multigrid Methods for the Euler Equations."

A brief description of the multigrid method will be given for a model 1-D problem. The convergence of the algorithm is studied through a local mode analysis and some questions and shortcomings of the multigrid Euler codes are discussed. Several ideas for possible improvement of the algorithm are given.

Dr. Avram Sidi, Israel Institute of Technology: "Convergence Acceleration Techniques for Vector Sequence."

We will survey the different methods of acceleration for vector sequences. The sequences of interest are those generated by using fixed point iterative techniques in solving large systems of linear or nonlinear equations such as those arising in the numerical solution of partical differential equations. A unified treatment of the different methods will be presented and some convergence results will be given.

Alex Solomonoff, Case Western University: "Behaviour of Boundary Layer with Moving Wall in an Adverse Pressure Gradient."

The potential flow about an airfoil is also a solution of the corresponding viscous flow if the correct boundary conditions are imposed. Since such boundary conditions are difficult to achieve in practice, we can ask how well they must be approximated to achieve approximately potential-flow performance. This involves investigating the behaviour of a boundary-layer flow where the wall moves. Some results based on similarity flows will be presented.

Dr. J. David A. Walker, Lehigh University: "Turbulent Flow at a Sharp Trailing Edge."

In conventional calculation methods for turbulent flows, a substantial number of the total mesh points as well as computational effort is required to adequately resolve the intense temperature and velocity profile variations that occur in the near wall region. In this presentation, an algorithm is discussed in which an outer region numerical solution is matched to a set of analytical profiles which describe the mean velocity and temperature profiles near the wall. These wall layer profiles are derived on the basis of the experimentally observed coherent structure of the near wall flow. In the calculation procedure, skin friction and heat transfer coefficients are obtained from algebraic relations which are the mathematical statements that the outer region numerical solutions merge smoothly with the wall layer profiles. Calculations are presented for a number of test cases for turbulent boundary layer flows. It is concluded that the present approach yields at least a 50 percent reduction in the total number of mesh points across the boundary layer (as compared to conventional methods) with no degradation in accuracy.

Dr. J. David A. Walker, Lehigh University: "An Embedded Function Algorithm for the Calculation of Turbulence Flows Near Walls."

The asymptotic structure of the flow field near a sharp trailing edge is described. Much of the near wake structure is shown to be independent of turbulence model. A solution for the near wake region is obtained using a relatively simple turbulence model.

RESEARCH AND CRITIQUE WORKSHOP

A workshop was held at NASA Lewis on August 15, 1986 to provide an opportunity for presentations of research results by ICOMP visiting reearchers to the ICOMP and Lewis staffs to the outside community. The workshop concluded with a review of the history of ICOMP presented by Dr. Eli Reshotko, Chairman of the Steering Committee, and an open forum allowing for a critique of ICOMP to that date and suggestions for its future activities. A list of the research presentations during the workshop is given below.

Dr. Lola Boyce, University of Texas-San Antonio: "Probabilistic Structural Analysis of a SSME Blade."

Dr. S.H. Chang, Cleveland State University: "Some Recent Mathematical Developments in Shock Capturing Schemes for Conversation Laws."

Professor Joseph Grady, Purdue University: "Dynamic Delamination in a Composite Laminate."

Professor John Lavery, Case Western Reserve University: "Frozen Coefficients and Newton's Method for Incompressible N-S Equations."

Dr. Avram Sidi, Israel Institute of Technology: "Application of Extrapolation Methods to Fluid Mechanics Codes."

M. Plesha, Wisconsin University: "Contact-Friction Constitutive Models for Finite Element Contact Problems."

Alex Solomonoff, Case Western Reserve University and Eli Turkel, Tel Aviv: "Global Collocation Methods for Approximation and the Solution of Differential Equations."

OVERVIEW OF 1987

Organizational Changes

The need for a full time ICOMP Director, stationed at NASA Lewis, has become apparent. To fill this need the Director's position was defined, and a search is under way to identify and hire a Director. In the interim, and in addition, Dr. Charles E. Feiler, recently retired from NASA Lewis, was appointed Executive Officer.

In order to give guidance to the ICOMP Steering Committee in planning for the future, an external Advisory Committee of distinguished leaders in the computational community has been formed. The Advisory Committee will meet at Lewis in the fall of 1987 for the purpose of examining the program and giving its consideration and opinions of how well ICOMP is meeting its objectives. The members of the Advisory Committee are: Dr. Ted Belytschko of Northwestern University, Dr. Earll Murman of M.I.T., Dr. J. Tinsley Oden of the University of Texas, Dr. Steven Orszag of Princeton University, and Dr. Stanley Rubin of the University of Cincinnati.

Visiting Researchers

During the current year there has been a mix of short term (several days to summer) and long term (one year) stays of visiting researchers, with the largest number of researchers being at ICOMP during the summer. This pattern is likely to continue during the coming year with some increase in the number of researchers.

There has been a major effort in providing office space at Lewis so that the ICOMP visitors can be located in one area for effective interaction, and also in providing convenient housing for visitors. This effort will be continued during the coming year.

Plans

The major activity of ICOMP is its continuing research directed toward improving computational methodology and capability. Its main products are the research results transmitted as reports within NASA and in the open literature, and the exchange of information and ideas during the course of the researchers' stays at ICOMP. In order to enhance this exchange of information and ideas a series of seminars given by ICOMP visitors has been held, in addition to seminars given by outside speakers. In addition, at the end of summer 1986 a workshop was held allowing for presentations of major research results by the visiting researchers, and a time for self-evaluation of the year's program.

ICOMP's seminar and workshop activities will continue and expand. Also other mechanisms will be sought to provide for broader interaction with the scientific community interest in ICOMP's areas of research, and for more rapid dissemination of research results.

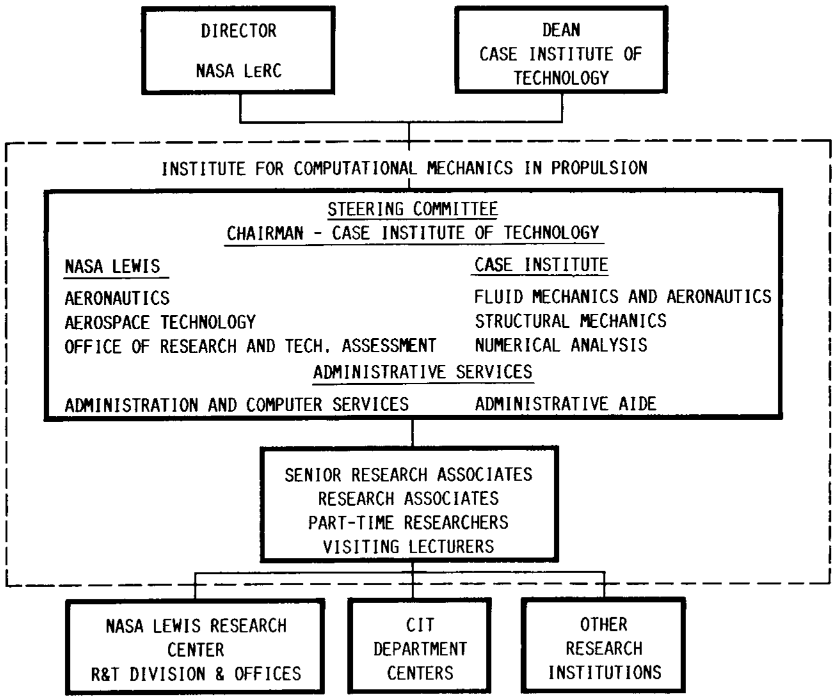

FIGURE 1. - ICOMP ORGANIZATION.

CHAIRMAN: PROFESSOR ELI RESHOTKO, CASE WESTERN RESERVE UNIVERSITY

LEWIS COORDINATOR: DR. LOUIS A. POVINELLI, INTERNAL FLUID MECHANICS DIVISION

NASA LEWIS	CASE INSTITUTE
MR. BRENT A. MILLER, INTERNAL FLUID MECHANICS DIVISION	PROFESSOR ISAAC GREBER, FLUID MECHANICS AND AEROSPACE
DR. LESTER D. NICHOLS, STRUCTURES DIVISION	PROFESSOR ROBERT L. MULLEN, STRUCTURAL ANALYSIS
DR. MARVIN E. GOLDSTEIN, CHIEF SCIENTIST	PROFESSOR JOHN LAVERY, NUMERICAL ANALYSIS

FIGURE 2. - ICOMP ORIGINAL STEERING COMMITTEE, 1985.

NAME/UNIVERSITY	MAY – DEC.
AKL, FRED - OHIO U. (S)	6/16-8/22/86
BOYCE, LOLA - TEXAS (S)	5/20-8/15/86
CHANG, SHIH-HUNG - CLEVE. ST. (F)	6/16-8/15/86
COWLEY, STEVEN - IMPERIAL COL. (F)	9/22-10/3
FIX, GEORGE - CARNEGIE-MELLON (F)	5/5-8/29/86
ELLIS, GE.KENNETH - VPI & SU (S)	12/1/86-11/30/87
GIVI, PEYMAN - FLOW RESEARCH (F)	9/1-9/30/86
GRADY, JOSEPH - PURDUE U. (S)	12/9/85-12/8/86
LAVERY, JOHN - CWRU (F)	5/12-7/13/86
LEE, SHIH-TUEN - NAT. TAIWAN (F)	7/1/86-8/31/87
LIN, CHIN-SHUN - IOWA STATE (F)	8/1/86-7/31/87
LYMAN, FREDERIC - SYRACUSE U. (F)	9/31/85-5/31/86
MEISTER, JEFFREY - AKRON U. (S)	10/1/86-9/30/87
PERIDIER, VALLORIE - LEHIGH (F)	7/21-8/22/86
PLESHA, MICHAEL - U. WIS. MADISON (S)	6/9-8/15/86
ROSE, MILT (F)	7/7-7/18/86
SCHAFFER, STEVEN - U. OF UTAH (F)	6/16-8/8/86
SIDI, AVRAM - TECHNION, ISRAEL (F)	6/30-8/31/86
SOLOMONOFF, ALEX - CWRU (F)	1/27/86-8/31/86
TURKEL, ELI - TEL AVIV, ISRAEL (F)	6/29/85-6/30/86
WALKER, J. DAVID - LEHIGH (F)	7/15-8/22-86
WEY, CHOWEN - GA. TECH. (F)	10/1/86-9/30/87
WHITFIELD, DAVID - MISS. ST. (F)	8/4-13/86

(S) STRUCTURES (F) FLUID MECHANICS

FIGURE 3. - ICOMP VISITING RESEARCHERS, 1985-1986.

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FIGURE 4. - SPRING 1986 ICOMP PARTICIPANTS. FRONT, LEFT TO RIGHT: F. LYMAN, SYRACUSE; G. FIX, CARNEGIE-MELLON; J. GRADY, PURDUE; J. LAVERY, CASE WESTERN RESERVE; BACK, LEFT TO RIGHT: I. GREBER, CASE WESTERN RESERVE; E. RESHOTKO, CASE WESTERN RESERVE; A. SOLOMONOFF, CASE WESTERN RESERVE; L. POVINELLI, NASA LEWIS RESEARCH CENTER, M. GOLDSTEIN, NASA LEWIS RESEARCH CENTER; E. TURKEL, TEL AVIV.

FIGURE 5. - SUMMER 1986 ICOMP PARTICIPANTS. FRONT, LEFT TO RIGHT: C. LIN, IOWA STATE; I. GREBER, CASE WESTERN RESERVE; L. BOYCE, UNIV. OF TEXAS; F. AKL, OHIO U., S. CHANG, CLEVELAND STATE; BACK, LEFT TO RIGHT: E. RESHOTKO, CASE WESTERN RESERVE; L. POVINELLI, NASA LEWIS RESEARCH CENTER; J. GRADY, PURDUE; M. PLESHA, WISCONSIN U.; J. LAVERY, CASE WESTERN RESERVE; AVRAM SIDI, TECHNION; A. SOLOMONOFF, CASE WESTERN RESERVE; D. WALKER, LEHIGH UNIVERSITY.

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16. Abstract

The Institute for Computational Mechanics in Propulsion (ICOMP) is operated jointly by Case Western Reserve University and the NASA Lewis Research Center in Cleveland, Ohio. The purpose of ICOMP is to develop techniques to improve problem-solving capabilities in all aspects of computational mechanics related to propulsion. The Institute began operation in 1985. This report describes the events leading to its formation, its organization and method of operation, and the technical activities of the first year.

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